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Research note: Group decision making using knowledge-based systems— An experimental study

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The authors present results of their preliminary study of the value of a knowledge-based system (KBS) on the effectiveness of group decision making in a business gaming environment. The authors developed a KBS that provided recommendations to the experimental groups regarding the quality of their decision making. The experiment involved 24 groups with 3-4 members per group. Twelve groups used the KBS in their decision making. The remaining groups were control groups. In KBS groups, the authors detected no significant effect on intragroup conflict, but found marginally increased group performance and decreased group member satisfaction and confidence with the decisions of their groups.

KEYWORDS: *knowledge-based systems; expert systems; business gaming; group decision making.*

The essence of group decision making is intragroup interaction. The important outcomes of any decision-making process include the effectiveness of the group in reaching a decision, the amount of conflict arising during the decision process, the confidence of the group members in the quality of their decision, and the satisfaction of the participants with the decision process. Advances in information systems and information technology make possible new forms of interaction among members of a group and new ways to measure the decision process itself.

We constructed an experiment to determine whether a knowledge-based system (KBS) could be effective in measuring the process of group decision making. The

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study provided an environment for decision-making groups in which (a) communications among group members could be controlled, and (b) tools were available to assist the group decision-making process.

This study provides a framework for using business gaming or simulation environment for the study of KBS effectiveness. This is a preliminary study conducted in a business gaming environment to investigate the effect of a KBS on group decision making. Using these results, we provide a design and framework for a larger study to test KBS effectiveness.

Technology Base of the Experiment

The technology base (i.e., KBS) used for the study was a computer program structured around specialized knowledge in a particular problem area, a symbolic language, and a knowledge base to provide a level of expertise significantly better than that of nonexpert humans.

Knowledge-Based System

Laudon and Laudon (1991) defined a KBS to be a knowledge-intensive program (software) that solves a problem normally requiring human expertise. A KBS can assist decision making, both individual and group, by asking relevant questions and explaining the reasons for adopting certain actions or providing recommendations.

There are four major elements in a KBS:

1. The *knowledge base* stores human knowledge about the solution of a problem.
2. A *KBS* (or expert system) is developed by a team of experts in the problem area, sitting together with knowledge engineers. Knowledge engineers perform the knowledge acquisition function and then translate this knowledge into a set of production rules, semantic networks, or frames.
3. The *shell* provides the expert system with an inference engine to search the knowledge base and provide a recommendation.
4. User(s) can have different roles relative to a particular KBS. The user can be the decision maker, with the KBS acting as an adviser. In other applications, decision making can be given over to the KBS entirely.

Theoretical Framework

The framework used for this study was based on the model proposed by Pinsonneault and Kraemer (1990). In our study, the technological support to the groups, in the form of a KBS, was the independent variable. Conflict was considered to be a process or intermediate variable, and group members' satisfaction with their decision, group performance, and members' confidence in their decisions were considered to be the dependent or outcome variables.

Technological Support

A few studies have examined the impact of KBS on groups. One study reported by Benbassat and Nault (1990) found that KBS augmented the information-processing capacity of the firm, altered the process of task execution, and increased the scope and formality of data used in the task. A comparative, pre-post exploratory design was used to examine the impact of three commercially used systems. They found that a KBS helped in managing complex decision-making environments, improving representation of data, improving standards, and providing a rigorous understanding of some of the previously uncertain parts of the tasks. By imposing structure on the decision process, the KBS introduced standard methodology into task performance. Overall, the KBS reduced the time required to make a decision, increased the quality of the decision, and increased satisfaction of group members with the decision. Because few studies have investigated the impact of KBS on group decision making, we made this the focus of our research.

Process Variable

Conflict

There have been studies investigating the impact of information technology, in particular, decision support systems (DSSs), on group decision making in a business gaming environment. In a study of three different problem-solving techniques in groups, Affisco and Chanin (1990) applied DSS technology for two of the techniques. They reported no significant differences in conflict handling between the various groups (DSS vs. non-DSS, problem-solving technology vs. control). Therefore, we hypothesize that if some groups are provided a KBS for group decision making (we call them KBS groups) and other groups are not, there will be no difference in the conflict in these groups compared with groups without any access to a KBS (we call them control groups). Therefore, we state our process hypothesis as follows:

Hypothesis 1: There is no significant difference in intragroup conflict between KBS and control groups.

Outcome Variables

Performance

Among the outcome variables, performance of groups has been the most widely studied variable. A few studies have examined the effect of computer-based decision making in a business gaming environment. Results have been inconclusive. Keys, Burns, Case, and Wells (1988) found that the use of computer-based work sheets led to only marginal improvement in performance over the use of hand-scored work sheets.

Wolfe and Gregg (1989) reported similar results. On the other hand, Affisco and Chanin (1989) found no significant relationship between the use of DSSs and group performance; that is, groups using DSS did not outperform non-DSS groups. Therefore,

Hypothesis 2: There is no significant difference in performance of KBS and control groups.

Satisfaction

Group members' satisfaction with their group decisions has not been widely studied in research involving information technology and its effect on group decision making. Benbassat and Nault (1990) found that KBS increased satisfaction of members with the group decision. In another study (Wolfe, Bowen, & Roberts, 1989), group cohesion was found to have a significant relationship to the satisfaction of group members with their decisions. Therefore, our null hypothesis is as follows:

Hypothesis 3: There is no significant difference in group members' satisfaction between KBS and control groups.

Confidence

Benbassat and Nault (1990) found that use of a KBS improves decision quality. Therefore, it is possible that use of a KBS increases the confidence of group members with their group decision. Other studies on the impact of information systems on group decision have not studied decision confidence in detail. Therefore, we state our final hypothesis as follows:

Hypothesis 4: There is no significant difference in group members' confidence in their decisions between KBS and control groups.

Methodology

This section discusses the methods used in our study to investigate the impact of KBS on group decision making. Participants were undergraduate students in a business policy course. Details of how the variables were operationalized, how the experiment was conducted, and data collection techniques are provided.

Operationalization of Variables

Technological Support

Technological support provided in the study was different for the study and control groups. A KBS provided technological support to the study group. Control groups

received no technological support. We developed the KBS, using the expert system shell, VP-Expert. The knowledge base was constructed from analysis of decision data from the firms (or groups) that had played the business game in the earlier semesters. A Group Decision Documentation questionnaire was administered two semesters prior to the experiment to determine the structure, order, and information requirements for the group decision. Groups were asked to identify strategies used during the course of the business simulation. Some personal interviews were conducted for clarification of strategies used.

The strategies for the game were incorporated as knowledge in the knowledge base of the KBS in the form of "if . . . then" rules. The KBS developed was tested and adjusted for one semester before the study was conducted.

Process

Conflict was the process variable in this study. Conflict is defined as the interaction of interdependent people who perceive incompatible goals and interference with each other in achieving those goals (Folger & Poole, 1984). Different methods of dealing with conflict are observed when conflict is generated as a part of a decision-making process. Blake and Mouton (1964) first presented a conceptual scheme for interpersonal conflicts by classifying modes into five types. Their scheme was further developed by Kilmann and Thomas (1977) and was then refined by Rahim (1983). Rahim conceptualized different styles of handling interpersonal conflict on two basic dimensions: concern for self and concern for others. The first dimension was the degree (high or low) to which a person attempts to satisfy his or her own concern. The second dimension was the degree (high or low) to which a person wants to satisfy the concern of others. A combination of the two dimensions results in five specific styles of handling interpersonal conflict:

Integrating (high concern for self and high concern for others): Integration results in confronting disagreements directly in a problem-solving manner.

Obliging (low concern for self and high concern for others): Obliging is characterized by smoothing over differences and focusing on areas of agreement.

Dominating (high concern for self and low concern for others): Dominating is characterized by forcing one's viewpoint at the expense of others.

Avoiding (low concern for self and low concern for others): Avoiding results by withdrawing from the conflict situation.

Compromising (moderate concern for self and moderate concern for others): Compromising is characterized by a search for a middle-ground solution.

This study investigated the effect of a KBS on Rahim's conflict-handling modes of group members.

Outcomes

Outcome variables used in this study were group performance, and satisfaction and confidence of group members with their group decision. Performance of a group in the

TABLE 1: Group Performance, Weighted Measures (in percentages)

<i>Item</i>	<i>Weight</i>
Rate of return on assets	20
Rate of return on equity	20
Stock price	10
Earnings per share	10
Retained earnings	15
Credit rating	5
Book value	5
Total	85

business game was determined by the performance of the firm it represented. A multivariate game performance index, as defined by Wolfe and Chanin (1994), was used as the performance indicator (see Table 1).

Satisfaction with the group decision is affected by the perception of group members about group processes and dynamics. This was measured using a Likert type scale in the postdecision questionnaire.

Confidence with the group decision, as used here, refers to the extent to which group members considered the decisions they made for the business game to be good decisions. Similar to satisfaction, confidence was measured using perceptual scores provided by individual group members in the postdecision questionnaire.

The Experiment

A controlled experiment was used in this study. The participants were undergraduate students enrolled in the capstone business policy course of a large public university. A total of 82 students (42 female and 40 male), aged 20-27, participated in this study. The gaming environment used was the Business Management Laboratory (Jensen, 1991). Students were randomly assigned to groups of three or four members. Each group operated as a firm in the business simulation. Performance in the simulation accounted for 30% of the student grade in the business policy course.

Each firm made nine decisions. The first decision was a trial decision, followed by four quarterly decisions for a simulated 2-year period. All firms were in the same position at the start of the simulation. Twelve firms were given the KBS and the remaining firms did not have access to any information technology; these were control groups.

Data Collection

Two instruments were used. A predecision questionnaire was administered at the start of the experiment, before students made their first decision. The Rahim Organizational Conflict Inventory II (ROCI-II) questionnaire was used. This instrument provided data about the students' predisposition toward conflict. The second instrument was a postdecision questionnaire, which was administered after all the decisions had

TABLE 2: Summary of Results

Hypothesis	Model			Treatment Means		
	Independent Variable(s)	Dependent Variable(s)	Model p Value	KBS	Control	Significance
1	Treatment	Conflict modes	0.6456	N.A.	N.A.	N.A.
	Treatment	Integrating	0.8762	-0.045	-0.058	N.S.
	Treatment	Obliging	0.0799**	-0.076	0.112	Significant**
	Treatment	Dominating	0.5925	0.108	0.196	N.S.
	Treatment	Avoiding	0.7483	-0.119	-0.062	N.S.
	Treatment	Compromising	0.945	-0.002	-0.009	N.S.
2	Treatment, conflict	Performance	0.2327	57.614	56.879	N.S.
3	Treatment, conflict	Satisfaction	0.0388*	4.913	5.543	Significant*
4	Treatment, conflict	Confidence	0.0929**	4.63	5.63	Significant*

NOTE: Conflict mentioned as a variable includes all conflict-handling modes: integrating, obliging, dominating, avoiding, and compromising. N.S. = not significant, N.A. = not applicable.

* $p < .05$. ** $p < .1$.

been completed. The postdecision questionnaire consisted of two parts. Part I was the ROCI-II, which provided data regarding the students' perception of conflict. These data when used with data collected from the predecision questionnaire gave an indication of the changes in conflict due to the presence or absence of an information technology for group decision making. Part II of the questionnaire focused on gathering data in group satisfaction and confidence. A performance index similar to the one used by Wolfe and Chanin (1994) was used to calculate the performance of each group (or firm) in the experiment. The index was constructed from a number of weighted measures. Table 1 shows the items in the performance index and the weight given to each item.

Results

Results of hypothesis testing are given in Table 2, which provides model significance or p values and treatment means for KBS and control groups, as well as information on whether the difference between treatment means was found to be significant.

Treatment or technological support provided to groups showed no impact on conflict within a group, except for the obliging conflict mode. The obliging mode was found to be higher in control groups. Treatment and conflict, in turn, were found to affect satisfaction and confidence of group members with their group decision, but did not have any effect on group performance. Both satisfaction and confidence of group members with their decision were found to be significantly higher in control groups compared with KBS groups.

Because we found no examples of research using KBS, we used other studies that investigated the impact of computer-based tools for group decision making in a

business gaming environment, as a reference for discussing our findings. Those results indicate that technological support provided to groups affected the obliging conflict mode but did not have a significant impact on other conflict modes. Our findings support, to some extent, the results obtained by Affisco and Chanin (1990) in which no difference was found in conflict-handling behavior between groups that used a DSS or did not use DSS for group decision making.

In this study, technological support and intragroup conflict were found to have no impact on performance. Performance of KBS groups was not significantly higher than non-KBS (or control) groups. Our findings support Affisco and Chanin (1990), who found no relationship between the use of a DSS and group performance. Our results do not support the findings of Keys et al. (1988) and Wolfe and Gregg (1989), who concluded that computer-based decision-making tools improve group performance. In short, our study adds to the already mixed results regarding the impact of information technology on group decision making in a business gaming environment.

We also found that technological support and obliging conflict mode have a significant impact on the satisfaction and confidence of group members with the group decision. Both satisfaction and confidence were found to be higher in control groups than KBS groups. One of the reasons for this could be the way a KBS works. A KBS provides recommendations based on its knowledge base. In our experiment, the KBS advised groups about decisions made in the business game; for example, the KBS mentioned whether the price chosen by the group was high, okay, or low. When KBS groups accepted the recommendations of the KBS, they were not making decisions on their own. It was as if they had another group member in the group. At times, the KBS appeared to be the dominant member of the group. This may have lowered the satisfaction and confidence group members had with their group decision.

Conclusion

This article provides results of a preliminary study on the effect of KBS on group decision making. We found that our results add to the already inconclusive findings on the effect of information technology in a business gaming situation. Because ours was a preliminary study with a small sample, we suggest the need for much larger studies to investigate the impact of KBSs, and information technology in general, on group decision making in a business gaming environment.

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